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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/687,098	10/15/2003	Peter-Pike J. Sloan	3382-66130	7230

26119 7590 03/09/2007

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EXAMINER	
XU, KEVIN K	
ART UNIT	**PAPER NUMBER**
2628	

SHORTENED STATUTORY PERIOD OF RESPONSE	MAIL DATE	DELIVERY MODE
3 MONTHS	03/09/2007	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

If NO period for reply is specified above, the maximum statutory period will apply and will expire 6 MONTHS from the mailing date of this communication.

Office Action Summary	Application No. 10/687,098	Applicant(s) SLOAN ET AL.
	Examiner Kevin K. Xu	Art Unit 2628

-- *The MAILING DATE of this communication appears on the cover sheet with the correspondence address* --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *04 January 2007*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-11* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-11* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Response to Arguments

Applicant's arguments filed 1/4/07 have been fully considered but they are not persuasive. Specifically applicant has argued that Sloan **teaches away** from producing *meso-scale radiance transfer* parameterized using low-order spherical harmonic lighting basis. Examiner respectfully disagrees. Firstly, it should be noted that Sloan explicitly teaches *macro-scale radiance transfer data* parameterized *using low-order spherical harmonic light basis functions*. (p. 527-530 introduction, sections 2-4, Figs 2-4). Although Sloan does not mention utilizing low-order spherical harmonic lighting basis functions for meso-scale radiance transfer per-se, Sloan **does not** teach using low-order spherical harmonic lighting basis functions can **only** be used to calculate macro-scale radiance transfer data ***nor*** does Sloan teach utilizing low-order spherical harmonic lighting basis functions for macro-scale radiance transfer necessitates that it is thusly impossible to use low-order spherical harmonic lighting basis functions for meso-scale radiance transfer. In other words, just because Sloan mentions using BRDF, which may utilize directional lighting basis (section 6 step 4 as mentioned by applicant) for glossy surfaces **does not absolutely exclude** the possibility (teaches away) of using low order-SH basis functions for any other means besides macro-scale radiance transfer (such as for meso-scale transfer data). Thus, examiner respectfully disagrees that Sloan teaches away from producing meso-scale radiance transfer data parameterized on spherical harmonic basis functions.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 1-2 and 9-10 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sloan ("Precomputed Radiance Transfer for Real-Time Rendering in Dynamic, Low-Frequency Lighting Environments") in view of Heidrich ("Illuminating Micro Geometry Based on Precomputed Visibility") in further view of Gardiner (5870098).

In regard to claim 1, Sloan teaches a computer graphics image rendering method, comprising of calculating data of macro-scale radiance transfer coarsely sampled over a surface of an object parameterized using a low-order spherical harmonic lighting basis (p. 527-530 introduction, sections 2-4, Figs 2-4). However, Sloan fails to explicitly teach calculating data of meso-scale radiance transfer finely sampled over a meso-structure texture patch mapped over a surface of the object. However, this is what Heidrich teaches. Heidrich teaches an inexpensive method for consistently illuminating height fields and bump maps, as well as simulating BRDFs based on precomputed visibility information, with this information we can achieve a consistent illumination across the **levels of detail**. (Abstract, lines 10-15) Although Sloan does not explicitly teach evaluating radiance transfer over at least a portion of the surface of the object from a lighting environment for a view direction based on a combination of the macro-scale radiance transfer data and the meso-scale radiance

transfer data and producing an image of the object as lit according to the radiance transfer evaluation, it would have been obvious to one of ordinary skill in the art at the time the invention was made to combine the teachings of calculating data of meso-scale radiance transfer sampled over a texture patched mapped over a surface as taught by Heidrich into the system of Sloan because the computation of meso-scale radiance transfer as taught by Heidrich allows for reduced scattering in the case where curved base geometry causes the valleys to widen up, and at the same time, more regions are shadowed (Lower left column of p. 462 and Fig. 11) and allows the use of geometry, bump maps as different levels of detail for a surface structure (Right column of p. 462) and therefore a more accurate 3-D model would be realized. However, neither Sloan nor Heidrich explicitly teaches area lighting. This is what Gardiner teaches. (Col 6 line 16-25, Fig. 1, Col 11 lines 44-51) It should be noted that Gardiner teaches global area lights project parallel rays emitted along direction vector of the global light source. It would have been obvious to one of ordinary skill in the art at the present time the invention was made to combine the teachings an area light source into the system of Sloan with the meso-scale radiance transfer of Heidrich in order to calculate data of meso-scale radiance transfer for area lighting at locations finely sampled over a meso-structure texture patch because an area light source provides the functionality of modeling the sun rays as an light source by emitting parallel rays of light and thus, a more realistic model of the sun can be achieved.

Regarding Claim 2, Heidrich teaches a computer graphics rendering method wherein meso-scale radiance transfer data is the height field by explaining the algorithm

is based on precomputation and reuse of visibility information in height fields, simulates both shadowing and indirect illumination, and is able to approximate the illumination as underlying base geometry changes. (Lower right column, p. 455) Heidrich further teaches an algorithm that computes illumination at a given surface point, but ignores indirect light from geometry other than the height field. (Lower left column, p. 457) It would have been obvious to one of ordinary skill in the art at the present time the invention was made to combine the teachings of height field into the system of Sloan for meso-scale radiance transfer data because height fields provide the functionality of simulating both shadowing and indirect illumination, giving an approximate illumination as the underlying base geometry changes. (p. 455 right column)

In regard to claim 9, Slocan teaches calculating data of macro scale radiance trans at locations coarsely sampled over a surface of an object wherein said macor scale radiance transfer data is parameterized using a low-order spherical harmonic lighting basis (p. 527-530 introduction, sections 2-4, Figs 2-4). Further, Sloan teaches a computer-readable data carrying media having encoded thereon computer executable instructions for performing a computer graphics image rendering method by explaining graphics hardware useful to capture radiance samples in a dynamic scene and precision issues and inability to do inner products in hardware force us to read back the sampled radiance images and project them in software. (Right column, p.532); said calculating data of **macro-scale** radiance transfer sampled over a surface of an object by explaining for efficiency, we precompute textures for the basis functions weighted by differential solid angle, B1(s) =y1(s)ds(s) each evaluated over the cube map

parameterization for s. The resulting integral then becomes a simple dot product of the captured samples of the incident radiance { Lp(s) } with the textures B1(s). Ideally, this computation would be performed on the graphics hardware. (Right column, p. 532) Sloan also teaches producing an image of the object as lit according to the radiance transfer evaluation by showing analysis shows that, assuming continuous bilinear reconstruction over the sampled 2D images, projection to 6-th order using 6×8×8 images yields 0.7% and 2% average and worst-case squared error, while 6×16×16 yields 0.2% and 0.5% squared error, and 6×32×32 yields 0.05% and 0.1% squared error. (Right column, p. 532) However Sloan fails to teach a computer readable data carrying media having encoded thereon computer-executable instructions for performing a computer graphics image rendering method, the method comprising calculating data of **meso-scale** radiance transfer finely sampled over a meso-structure texture patch mapped over a surface of the object. This is what Heidrich teaches. Heidrich teaches utilization of graphics hardware for an additional performance gain, assuming standard OpenGL like graphics pipeline with some extensions and to implement the pixel texture extension in software. (Right column, p. 458) Furthermore, Heidrich teaches the scattering of light via two points p and q in the height field first requires us to compute the direct illumination in q. If we do this for all grid points we obtain a texture Ld containing the reflected light caused by the direct illumination in each point. This texture Ld is generated using **the bump mapping mechanism the hardware provides**. Referring to figure 5, the second texture Ld contains reflected direct light in each point, which acts as an incoming radiance at p. (Left column, p.459)

Although Sloan does not explicitly teach evaluating radiance transfer over at least a portion of the surface of the object from a lighting environment for a view direction based on a combination of macro-scale radiance transfer data and meso-scale radiance transfer data, it would have been obvious to one of ordinary skill in the art at the time the present invention was made to combine the teachings of calculating data of meso-scale radiance transfer sampled over a texture patched mapped over a surface as taught by Heidrich into calculating data of macro scale radiance transfer sampled over a surface taught by Sloan because the computation of meso-scale radiance transfer as taught by Heidrich allows for reduced scattering in the case where curved base geometry causes the valleys to widen up, and at the same time, more regions are shadowed (Lower left column of p. 462 and Fig. 11) and allows the use of geometry, bump maps as different levels of detail for a surface structure (Right column of p. 462) and therefore a more accurate 3-D model would be realized. However, neither Sloan nor Heidrich explicitly teaches area lighting. This is what Gardiner teaches. (Col 6 line 16-25, Fig. 1, Col 11 lines 44-51) It should be noted that Gardiner teaches global area lights project parallel rays emitted along direction vector of the global light source. It would have been obvious to one of ordinary skill in the art at the present time the invention was made to combine the teachings an area light source into the system of Sloan with the meso-scale radiance transfer of Heidrich in order to calculate data of meso-scale radiance transfer for area lighting at locations finely sampled over a meso-structure texture patch because an area light source provides the functionality of

modeling the sun rays as an light source by emitting parallel rays of light and thus, a more realistic model of the sun can be achieved.

Regarding claim 10, Sloan teaches the computer-readable data carrying media wherein the global effects comprise of self-shadowing and interrelection by showing the resulting precomputed model allows run-time changes to lighting, with correct shadowing and interrelections in any low-frequency lighting environment (Left column of p.533 and Fig. 6)

Claims 3-8 and 11 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sloan ("Precomputed Radiance Transfer for Real-Time Rendering in Dynamic, Low-Frequency Lighting Environments") in view of Heidrich ("Illuminating Micro Geometry Based on Precomputed Visibility") and Gardiner (5870098) in further view of Tong ("Synthesis of Bidirectional Texture Functions on Arbitrary Surfaces").

Consider claim 3, the teachings of Sloan and Heidrich are given in the previous paragraphs of this office action. However, both Sloan and Heidrich fail to teach a computer graphics image rendering method wherein calculating the meso-scale radiance transfer data comprises of producing a radiance transfer texture encoding response to incident lighting in a direction and at a location on the meso-structure texture patch and expressed as a **lighting basis function** and producing a spatial index map to map the locations on the meso-structure texture patch onto the surface of the object, via a **precomputed texture synthesis**. Nevertheless, this is what Tong teaches. Tong teaches real –world textures arise from both spatially variant surface reflectance and surface mesostructures, which are responsible fro fine-scale shadows,

occlusions and specularities. (Left column of p. 665) Furthermore Tong teaches a possible way to achieve a consistent mesostructure on a surface is to directly apply **surface texture synthesis** techniques to surface BTF synthesis (Left column of p. 666) and the surface texton space S is the inner-product spanned by using the 3-D textons {t1....tn} as **basis vectors**. (Left column of p. 667) Although neither Sloan nor Heidrich explicitly teaches producing a radiance transfer texture expressed as a lighting basis function and producing spatial index map to map locations on the meso-structure patch via texture synthesis, it would have been obvious to one of ordinary skill in the art at the time the present invention was made to combine the teachings of calculating data of macro-scale radiance transfer coarsely sampled over a surface as taught by Sloan, calculating data of meso-scale radiance transfer finely sampled over a meso-structure texture patch as taught by Heidrich and producing radiance transfer expressed as a lighting basis function and producing spatial index on the meso-structure texture patch via precomputed texture synthesis as taught by Tong in order to exhibit a consistent mesostructure when viewing and lighting directions change and to better describe real-world textures and enable the user to decorate real-world geometry with real-world textures (Left column of p.672) and accordingly, by incorporating the teachings of Tong with Sloan and Heidrich, a even more accurate 3-D model would be realized.

Claim 4 is a simply a combination of claims 1, 2 and 3 except for the recitation of area lighting of the objects surface. This is what Gardiner teaches. (Col 6 line 16-25, Fig. 1, Col 11 lines 44-51) It should be noted that Gardiner teaches global area lights project parallel rays emitted along direction vector of the global light source. It would

have been obvious to one of ordinary skill in the art at the present time the invention was made to combine the teachings an area light source into the system of Sloan with the meso-scale radiance transfer of Heidrich in order to calculate data of meso-scale radiance transfer for area lighting at locations finely sampled over a meso-structure texture patch because an area light source provides the functionality of modeling the sun rays as an light source by emitting parallel rays of light and thus, a more realistic model of the sun can be achieved.

Regarding claim 5, Sloan teaches the representation of radiance transfer of the object's surface sampled at macro-scale is a pre-computed radiance transfer matrix by showing both incident radiance and transfer functions in a linear basis, we exploit the linearity of light transport to reduce the light integral to a simple dot product between their coefficient vectors (diffuse receivers) or a simple linear transform of the lighting coefficient vector through a small transfer matrix for glossy receivers (Right column of p. 527). Furthermore Sloan teaches if the object is glossy, a transfer matrix is applied to the lighting coefficients to produce the coefficient of a spherical function representing self-scattered incident radiance at each point. (left column of p.529).

Regarding claim 6, Heidrich teaches the method wherein the representation of radiance transfer of a meso-structure of the object's surface sampled at meso-scale is a radiance transfer texture by showing the incoming radiance is not determined by the intensity of the light source, but rather by the content of the Ld texture. (Left column, p. 458) It would have been obvious to one of ordinary skill in the art at the present time the invention was made to combine the teachings of radiance transfer texture into the

system of Sloan in order to represent radiance transfer of meso-structure of the object's surface sampled at meso-scale because textures provide the functionality of adding realism to a computer-generated graphic and thus, a more accurate 3-D model can be achieved.

Consider claim 7, Heidrich teaches the representation of radiance transfer of a meso-structure of the object's surface sampled at a meso-scale comprises a radiance transfer texture encoding response at a location on a meso-structure patch in a direction to incident lighting, and a spatial index map mapping from locations on a the surface of the modeled object to locations on the meso-structure patch, and wherein the spatial index map operates as an index to the radiance transfer texture by explaining incident illumination at any given surface point, and obtaining the reflected radiance for that point and a given viewing direction (right column of p. 457) and use of the hardware algorithm to compute higher dimensional data structures, such as light fields [8, 18] and both space variant and space invariant Bidirectional reflectance distribution functions, BRDFs. (Right column of p. 461) It would have been obvious to one of ordinary skill in the art at the present time the invention was made to combine the teachings of a spatial index map into the system of Sloan in order to map locations on surface of modeled object to location son the meso-structure patch because in order to further improve performance slightly, the approach can completely get rid of geometry for computation of BRDF samples, and work in texture space. (p. 462 left column)

Consider claim 8, Sloan teaches a function of radiance transfer texture comprising of a view direction to incident lighting by explaining the computing of transfer

field over the object's surface in 3D rather than over a fixed 2D view to allow viewpoint changes. (Left column of p. 528) Sloan also teaches of a precomputed radiance transfer matrix encoding radiance response of the location on the surface of the modeled object to incident lighting L of the light environment by showing the matrix transforms the lighting coefficients into the coefficients of a spherical function representing transferred radiance (Fig. 2, p. 528 and equation 9, p. 530) However, Sloan fails to teach the function of radiance transfer encoding response indexed via an id map that maps locations on the surface of the modeled object to locations on the meso-structure patch. This is what Tong teaches. Tong teaches **from the surface texton map tout and the sample BTF T, we can efficiently render the BTF on the target mesh M** as follows. First, we compute the viewing and lighting directions for each mesh vertex v in its local texture coordinate frame from the given light source location and the viewpoint. Vertices occluded from either the light sources or the viewpoint are ignored. Then, a set of nearby images are found from the BTF sample T. Using v's texture coordinate, we can look up colors from this set of images and blend them to get the color of v. With all vertex colors obtained, the mesh can be sent to the graphics pipeline for display. This procedure repeats for every novel lighting/viewing configuration. (Left column of p. 670) Although Sloan does not explicitly teach the function of radiance transfer texture indexed via an id map that maps locations on the surface of the modeled object to locations on the meso-structure patch, it would be obvious of one of ordinary skill in the art at the time of invention to calculate radiance transfer texture encoding response as taught by Sloan as a function of the mapping of

locations on surface of modeled object to locations on the meso-structure patch as taught by Tong in order to efficiently render bidirectional texture function (BTF), which describes textures arising from both spatially variant surface reflectance and surface mesostructures (Abstract, p. 665) and exhibits a consistent mesostructure when viewing and lighting directions change (Left column of p. 672), and thus a more accurate 3-D model would be realized.

Claim 11 is simply a combination of claims 1, 2, 3 and 7 except for the addition of a display driver operating to present the image of the modeled object in the lighting environment, which is taught by Heidrich. Heidrich teaches a framebuffer which is read out to main memory, and each pixel is replaced by a value looked up from a texture, using previous contents of the pixel as texture coordinates. (Right column of p. 458) It would have been obvious to utilize a display driver into the system of Sloan because a display driver provides the functionality of converting the more general input/output instructions of the operating system to messages that the display can understand. It should be noted that Sloan teaches a set of macro-scale radiance transfer matrices and radiance transfer texture as indexed by the id map. (p. 530 right column, p. 531 left column)

Conclusion

THIS ACTION IS MADE FINAL. Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within

TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Kevin K. Xu whose telephone number is 571-272-7747. The examiner can normally be reached on 8:30AM - 5:00 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Mark Zimmerman can be reached on 571-272-7653. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

KX

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3/2/07

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